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ILYOCRYPTUS GOULDENI, A NEW SPECIES OF WATER FLEA, AND THE FIRST AMERICAN RECORD OF *I. AGILIS* KURZ (CRUSTACEA: CLADOCERA: MACROTHRICIDAE)

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Abstract.—*Ilyocryptus agilis* Kurz, 1878, is reported from the Potomac River, Maryland, the first record in the New World. Specimens were compared with *I. agilis* from the Lilljeborg collection, Zoological Museum, Uppsala, Sweden, for verification. A detailed description of the trunk limbs and feeding habits of *I. agilis* are presented here for the first time. A new species, *Ilyocryptus gouldeni* (type-locality: Anacostia River, near Washington, D.C.) is also described here along with observations of live animals.

Ilyocryptus agilis Kurz, 1878, once thought to be strictly a European form, has actually developed a substantial-sized population in the eastern United States, unknown until 1974.

Kurz (1878) first described this species from samples taken in a mill pond in Bohemia. The first British record was by Scourfield (1894) from the Victoria Regia tank in Regent's Park, London, England. Other recordings followed shortly from the Byre River in east Norfolk, Great Britain (Gurney, 1907), and from Sweden (Lilljeborg, 1900).

More recent records indicate that *I. agilis* is distributed extensively in European countries, including Scotland, France, Italy, Czechoslovakia, Hungary, Poland, Romania, Denmark, Finland, China, and Russia (Flossner, 1972; Smirnov, 1976). The discovery of *I. agilis* on the eastern coast of the North American continent was unexpected as for quite some time it was considered rare even in Europe (Kurz, 1878).

The first specimens recorded in the U.S. were from the stomach contents of juvenile white perch (*Morone americanus*). The fish were collected in the lower Potomac River estuary from river mile 60 (Sta. 18 area) to river mile 99 (12 miles north of Sta. 24) (Fig. 1), during the summer of 1974 (Sage, Summerfield and Olson, 1976).

The number of *I. agilis* found per gut ranged from 1–10 with a total of 32 found in 3 fish guts combined from station 18 (Fig. 1). The cosmopolitan macrothricid, *I. sordidus*, was consistently found in association with *I. agilis* in the fish guts. The 2 species were routinely found inhabiting the same locations, though *I. sordidus* has a consistently higher number of individuals, with a maximum of 191 specimens found at station 22. This finding corresponds nicely to those of Chirkova (1972) who stated that *I. sordidus* has a tendency to "nest" so that the young, when leaving the brood

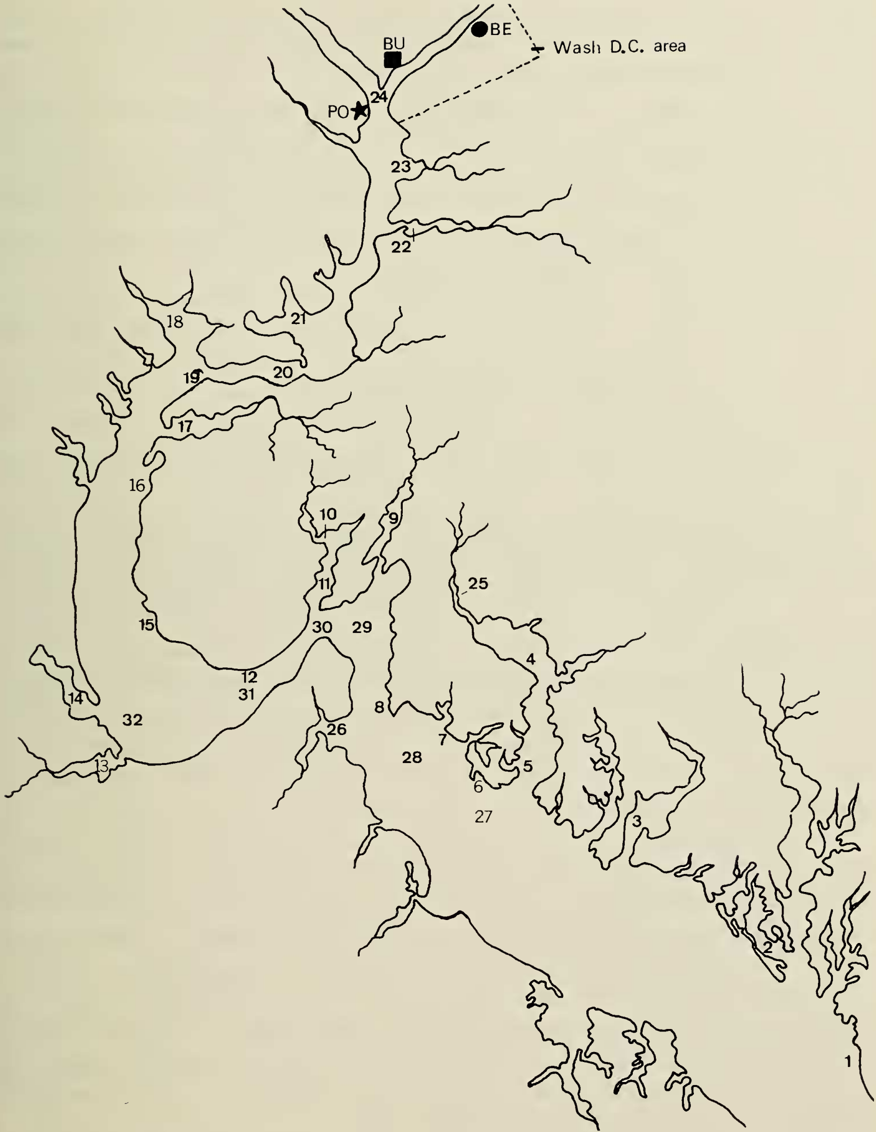

Fig. 1. Lower Potomac River, showing field stations and locations of the 3 electric generating stations: BE, Benning Road; BU, Buzzard Point; PO, Potomac.

pouch in the mud, do not swim away, but remain in the same area, producing as many as 11,000 individuals per cubic meter, whereas the surrounding area may not be populated. Comparative studies on the nesting tendency of *I. agilis* have not yet been attempted.

Both animals constituted a significant part of the stomach contents of the juvenile white perch, which suggests that they are an important food item for this, and perhaps other, benthic feeders.

During the summer of 1975, plankton samples were taken in the vicinity of 3 electric generating stations in the Washington, D.C., area. *I. agilis* was found at all 3 locations. The Buzzard Point Plant location (Fig. 1) had the highest densities (500/m^3 in one replicate of one sample); *I. agilis* was found, unexpectedly, in *surface*, as well as mid-depth and bottom plankton samples during both the day and night.

Washington, D.C., presents one of the most fascinating examples of coexistence of these macrothricids encountered in our studies. For example, at the Benning Road site, there were 4 species of *Ilyocryptus* present and occasionally all 4 were found in the same sample! The 4 species were the American *I. spinifer*, the cosmopolitan *I. sordidus*, the European (and now U.S.) *I. agilis*, and a new species *I. gouldeni*, described herein.

The waters at this site are quite turbid and have an extremely high nutrient content. This probably lessens interspecific competition because the tolerant *Ilyocryptus* species can surivive in fairly polluted waters which do not permit the survival of most benthic animals. Healthy specimens of *I. sordidus* have been found in oxygen-poor mud and foul organic matter. A physiological adaptation of sufficient hemoglobin in their blood enables them to survive these conditions and gives them their characteristic red body color (Fryer, 1974). Hemoglobin is also present in *I. gouldeni*, which has been found living in an environment similar to that preferred by *I. sordidus*.

Complete shedding of the old carapace when molting enables *I. agilis* and *I. spinifer* to swim and feed in the water column despite the excessive amounts of detritus because they are not burdened by "old clothes" of incompletely molted shells, as is *I. sordidus*. This directly reduces competition with their benthic relatives, *I. sordidus* and *I. gouldeni*.

According to Kurz (1878), *I. agilis* uses its antennae in rapid, unsynchronized strokes, enabling it to swim feebly in the water. The presence of *I. agilis* in surface as well as in mid-depth and bottom samples, suggests, however, that this animal is a more active swimmer than previously thought (Scourfield, 1894; Fryer, 1974).

I. agilis young swim almost continuously, rarely attaching themselves to the bottom, and are most often found at the surface (air)–water interface, exhibiting almost copepod-like behavior. The older, larger individuals swim occasionally, then settle on their backs (as in *I. sordidus*) and filter water through their food chambers. Apparently because there is less detritus on the shell, there is less antenna action sweeping across the shell opening to keep it clean. *I. agilis* appears to seek food more actively than *I. sordidus*, a passive filter feeder (Fryer, 1974). Animals observed exhibited a unique method of feeding compared with other macrothricids (Sergeev, 1973). The *I. agilis* swim until they come into contact with a suitable detritus deposit; they then use their antennae to bury themselves head first just under the surface of the detritus, where they remain without moving their antennae, simply filtering water and food particles through their food chamber. This resting, filtering activity generally lasts only a few minutes; then *I. agilis* begins swimming again. This frontal approach differs greatly from that of *I. sordidus* which continuously drags itself along on its back and occasionally with what seems to be great effort, rolls over and buries itself deeper in the detritus.

Ilyocryptus agilis Kurz, 1878
Figs. 2–3

Ilyocryptus agilis Kurz, 1878:406.—Scourfield, 1884:429.—Sars, 1890:45.—Lilljeborg, 1900:332.—Stingeline, 1908:82.—Kielhack, 1909a:62.—Arevalo, 1916:50 (var. *longisetus*).—Romijn, 1919:536.—Wagler, 1937:44.—Behning, 1941:204.—Herbst, 1962:72.—Sramek-Husek, 1962:289.—Manujlova, 1964:204.—Flossner, 1972:238.—Smirnov, 1976:50.

Material examined.—Potomac River, Maryland, near Washington, D.C., USNM 170540. James River, Virginia, near Williamsburg, USNM 170541. Walloxen, Sweden, Lilljeborg collection #1053, 1054. Malma, Sweden, Lilljeborg collection #1055.

Diagnosis.—The size range of the *I. agilis* found in the eastern U.S. is .5–1.2 mm, about .2 mm larger than the maximum size reported from Europe. This size range includes females only, as no males from this continent have yet been found. The color is often a pale horn yellow (Kurz, 1878), but they also have a tendency to be pale and almost translucent as in Scourfield's (1894) specimens from England. The head is small in comparison with that of *I. sordidus.* The complex eye is close to the forehead, the ocellus positioned near the rostrum. The sensory antennules (first antennae) are long, slender and equal in length, the length equal to the distance from their bases to the forehead. They are two-segmented, and bear numerous apical sensory setae which are unequal in length.

The second antennae are longer and slimmer than those of *I. sordidus,* and not quite so long as those of *I. spinifer.* There are 3 long and 1 short setae on each end segment, and a single seta, slightly feathered, on the second and first segments. The coxa is strong and well developed. There are single short spines on the anterior side of both the proximal and the distal segments as in the Russian forms described by Smirnov (1976).

The shell molt is complete in this species. Due to the complete shedding of the old shell, there is only one row of setae on the rim of the shell. The

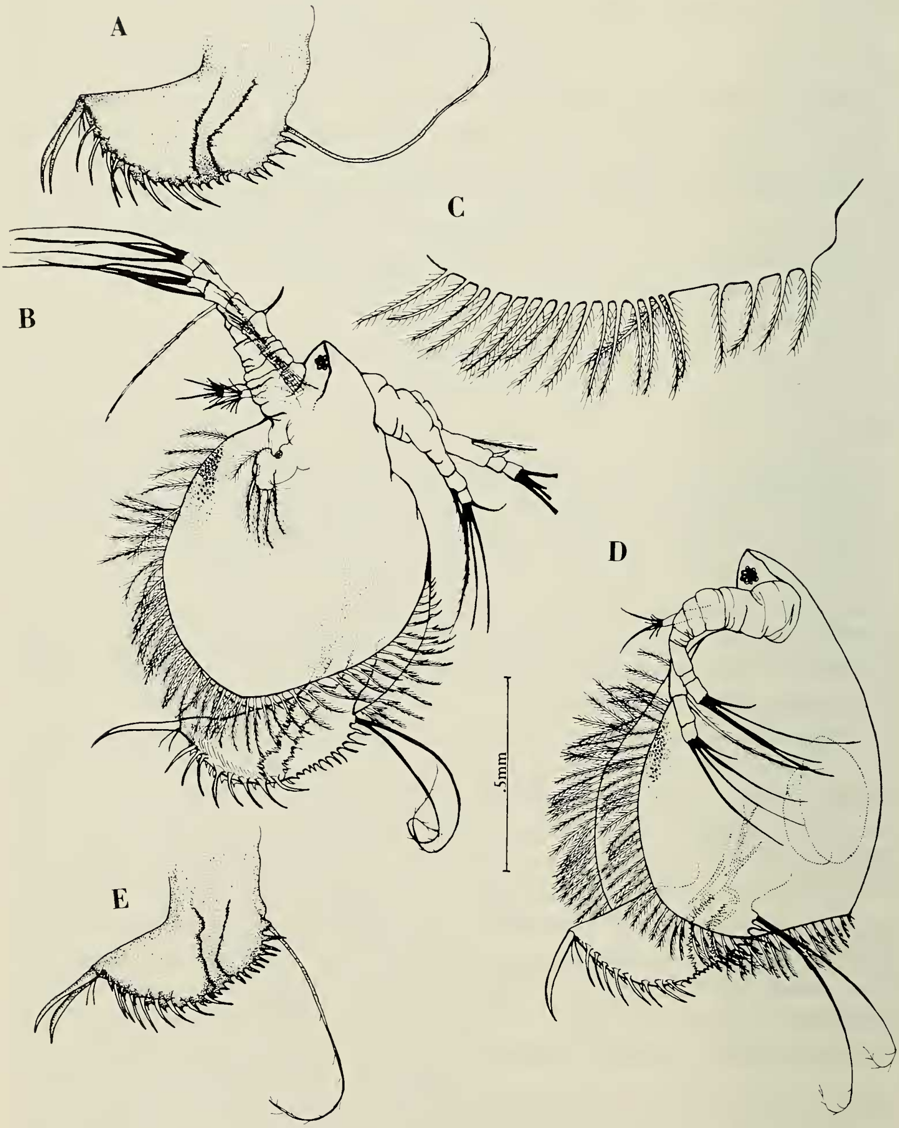

Fig. 2. *Ilyocryptus agilis*, female. A, Postabdomen, Potomac River, Maryland; B, Adult, Potomac River, Md.; C, Medial view, anterior rim of shell, (4,000×) showing placement of fifth seta; D, Adult, Walloxen, Sweden; E, Postabdomen, Walloxen, Sweden.

setae on the anterior part of the shell (near the antennae) are finely feathered, while those on the posterior margin are pectinate, though simply (Fig. 2B).

Kurz (1878) states that one of the distinguishing features for separating *I. agilis* from other members of the genus is the fifth seta on the anterior margin of the shell. The seta is always directed posteriorly and laterally toward the back and out, crossing over the following setae. A medial view of the shell indicating placement of this seta is shown in Fig. 2C. Examination of European specimens from the Lilljeborg collection (Sweden) showed the European form to be identical in this feature (Fig. 2D).

The postabdomen is large and quite broad. The claws are quite long and slightly curved, with a fine row of minute setae on the underside. There are 2 fine sense hairs at the base of each claw. Between the claw base and the first marginal spine are 4–5 minute setae placed on the lateral edge of the postabdomen. The anal opening is placed more toward the posterior of the postabdomen, the distal curve being much greater than the curve of the proximal part (Fig. 2A).

On the distal curve are 8 long spines, slightly curving toward the rear of the postabdomen. These spines decrease in length as they near the anal opening. Along the anal furrow is a row of about 14 small marginal teeth between the longer curved spines. This row of marginal teeth begins near the base of the claws and continues across the anal opening to the beginning of the proximal curve of the postabdomen. The proximal curve bears a series of 6–8 spines graduating in length (and breadth), from the anal opening to the base of the anal sensory setae. These spines can be simply curved or leaf-shaped, as described by Kurz (1878) and reiterated by Scourfield (1894) who indicated he had seen both types in his collections. Specimens from the United States are of both types as well. The reason for the variation is unknown.

In comparing the European and American forms of *I. agilis*, there seems to be a consistent difference in the number of spines on the proximal part of the postabdomen. The American form (Fig. 2A) tends to have 6–7 preanal spines, while the European form (Fig. 2E) tends to have 7 or 8 spines. The spines are otherwise identical in placement and shape

There is a long, lateral sense hair located on the male's antennule approximately three-fourths of the way up from the base (Fig. 3, A1). This feature has been used to differentiate males from females in *I. agilis* and other members of the genus. The length and placement of this seta varies from species to species, making this a useful key characteristic.

Although to date no males of *I. agilis* have been found in the U.S., a European specimen from the Lilljeborg collection (1900) in Sweden was examined. The postabdomen of the male seems somewhat longer, as does the body, and there are 6 small median teeth across the anal opening, in

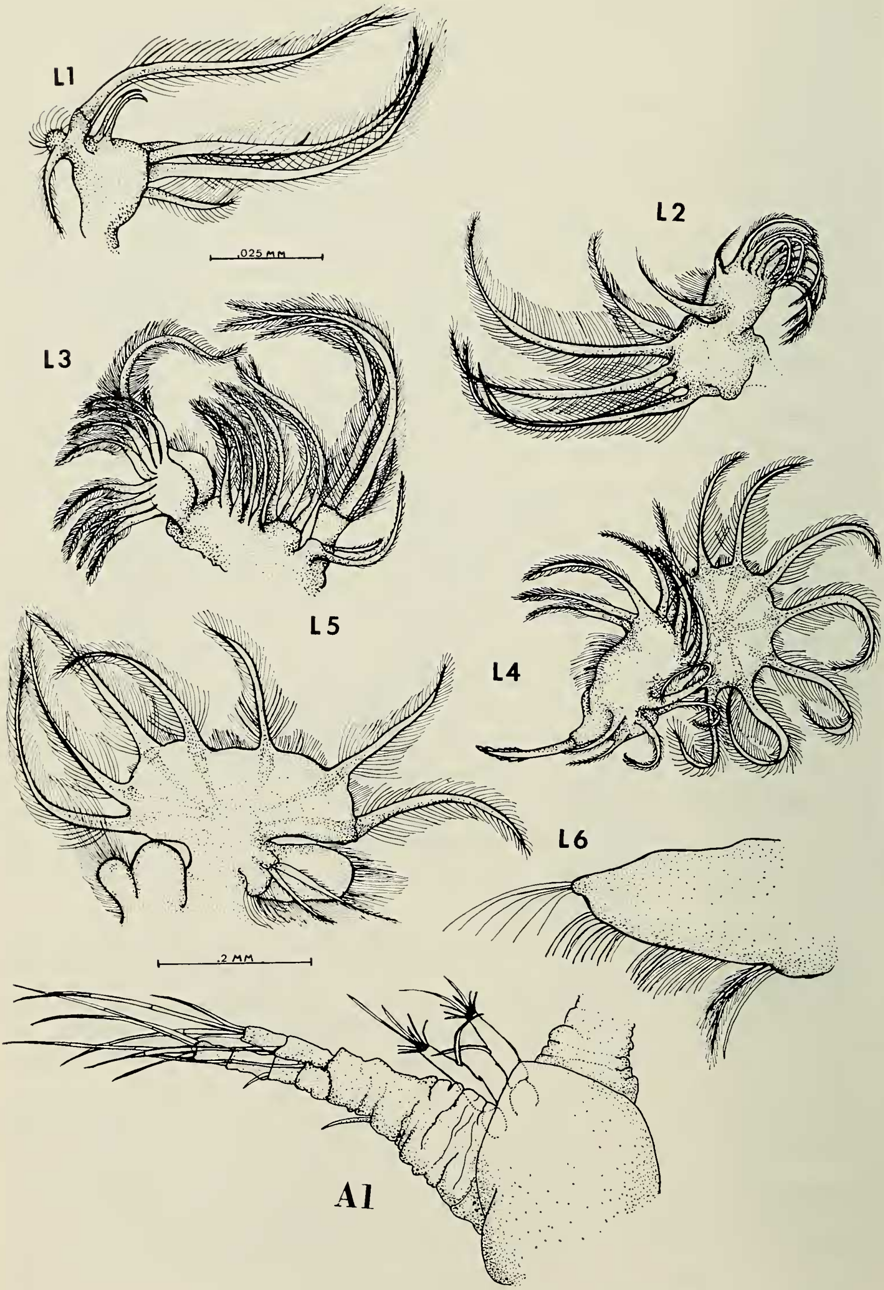

Fig. 3. *Ilyocryptus agilis*. L1–L6, Thoracic limbs, female, adult, Potomac River, Md.; A1, Antennule of male *I. agilis* from Sweden, showing placement of lateral seta.

Fig. 4. World map showing known distribution of *Ilyocryptus agilis.*

contrast to the females examined which have only 4 of these teeth. This may not be a consistent male characteristic as only one male specimen was examined.

The trunk limbs of *I. agilis* are virtually identical to those of the other members of the genus. During the time that these individuals are resting on the bottom filtering for food, their limbs act in the same manner as those of *I. sordidus* (Fryer, 1974, Sergeev, 1973). Detailed camera lucida drawings of the trunk limbs are given in Fig. 3. A thorough description of the function and purpose of each limb is given in Fryer's (1974) monograph on the evolution and adaptive radiation of the Macrothricidae.

Ilyocryptus gouldeni, new species
Fig. 5

Material examined.—Holotype, female (USNM 170599). Type-locality: Anacostia River, Maryland, near Washington, D.C., 38°50′N, 76°57′W, collected from bottom, near shore, in shallow freshwater area with detrital mud benthos, by Judith L. Williams, and Scott Zeger, August 1977. Paratypes: 4 females (USNM 170602) from type-locality, collected by J. L. Williams, August 1975; 3 females (USNM 170601) from a pond in Orange, Texas, collected by Clyde E. Goulden, April 1975; 5 females (USNM 170600) from Tidemill Marsh, James River, Virginia, collected by Katie Munson, August 1977.

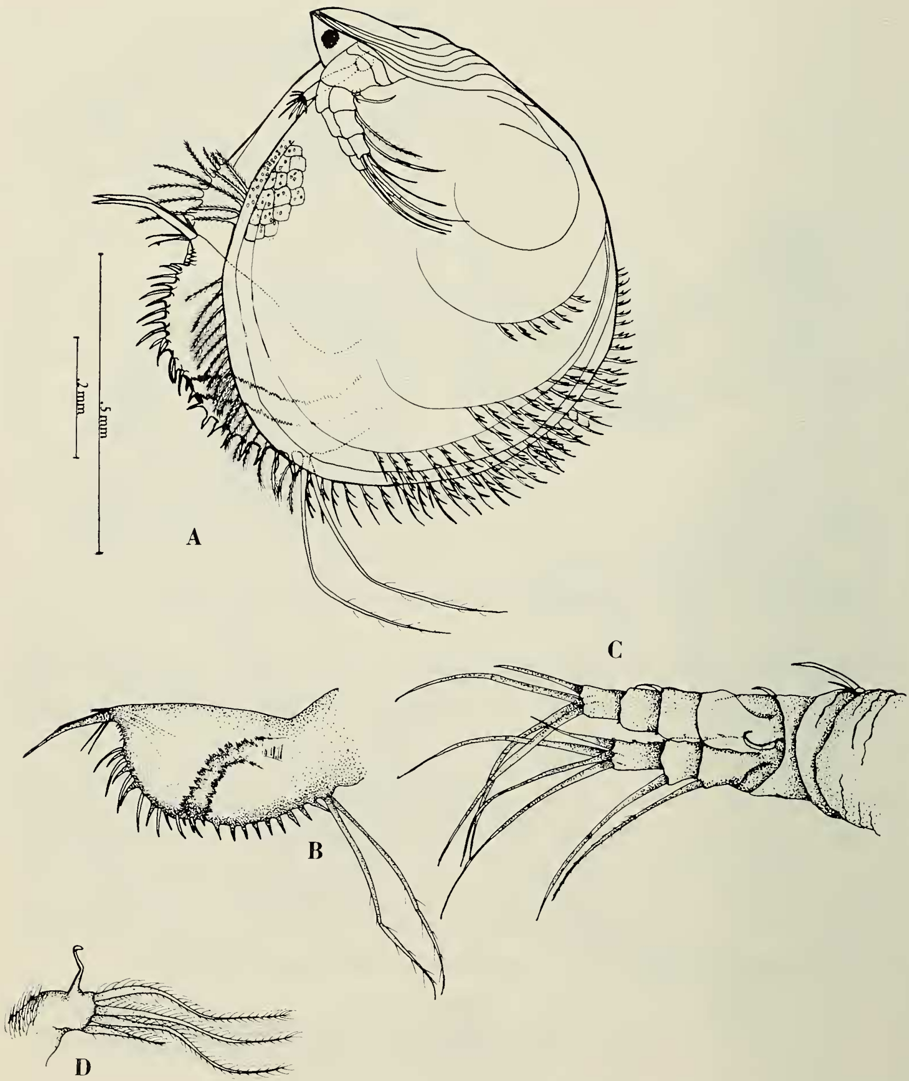

Fig. 5. *Ilyocryptus gouldeni.* A, Adult female, James River, Va.; B, Postabdomen, female; C, Antenna (second), female; D, Ejector hook of first thoracic limb.

Diagnosis.—Female: The lateral view is generally oval. The ventral edge of the shell is slightly convex and the body appears wedge-shaped, as the angle from the dorsal to the ventral edge of the shell decreases greatly. The head region tapers anteroventrally to form a triangle. The shell molts are incomplete, causing a buildup of 2–5 old carapaces, each bearing the heavily barbed protective setae found on the posteroventral rim of the shell, as in *I. sordidus* (Fryer, 1974). The valve is reticulated in a hexagonal pattern, in combination with numerous minute dots covering the surface. The dorsal region of the headshield shows 3–5 heavily cuticular layers fused together. The eye is located in the anteroventral part of the head, along with the large ocellus, situated above the eye. The antennae are short, the basal segment very strong, and well developed for rowing through detritus. There is a heavy spine used for burrowing on the dorsal part of the annulated base of the antennae.

The distal part of the antenna has 2 branches with setae (0-0-0-3/1-1-3) and spines (0-1-0-1/0-0-1) and a series of small barbs located on the ventral part of the 3-segmented branch. The antennules are long, 2-segmented, with numerous (7–10) apical sensory setae, unequal in length. The postabdomen is large, twice as long as wide, with a slight sinuation in the midventral part at the anal opening. The proximal part is slightly convex, and bears 8–9 spines, decreasing in length slightly as they near the anal opening. There are 2–4 small spines across the anal opening. The distal part of the postabdomen is convex, and heavily spined. There are 6–7 large marginal denticles, beginning at the anal opening and ending just before the last lateral spine near the base of the claw. There are 7 long lateral spines decreasing slightly in length proximally. Located between the base of the claws and the first lateral spine are 4–5 minute spinules, decreasing in length distally. The claws are long, and bent at a slight angle at midlength. There are 2 small basal spines located on the dorsal part of the claws and 2 long, fine basal setae on the underside of each claw. The natatory setae consist of a long basal segment and a shorter distal segment armed with a long, fine seta.

The 6 trunk limbs are similar to those of other species in this genus, and are relatively stout as in its burrowing relative, *I. sordidus*. There is a slight difference in the shape of the ejector hook (Fig. 5D), located on thoracic limb I, in comparison with other members of *Ilyocryptus*. The length of the female (holotype USNM 170599) is 0.80 mm. The color of the body is red-orange indicating the presence of hemoglobin, as in *I. sordidus*, for increased tolerance of environments with low levels of dissolved oxygen.

This animal burrows in the detritus and feeds in a manner almost identical to that of *I. sordidus* and is known to cohabitate with this and other members of the genus in extremely close proximity (personal observation).

Male: Unknown.

Remarks.—When observed live, in the detritus, this species is virtually indistinguishable from *I. sordidus*. Only upon careful examination of the postabdomen can the two be separated. The distinct flexure in the claw

Fig. 6. United States, showing known distribution of *Ilyocryptus gouldeni.*

and the number of curved preanal (proximal) spines are the most obvious and most useful characteristics by which to distinguish *I. gouldeni* from the other *Ilyocryptus.*

Etymology.—This species is named after Clyde E. Goulden, whose assistance and encouragement made this work possible.

Discussion

In an effort to describe the geographical range of *Ilyocryptus* across the United States, whole zooplankton samples from private collections were examined. In 1976, samples from Dr. D. Frey's private collection (Indiana University); the S. F. Light collection, borrowed from the Smithsonian Institution; the Gulf Coast Research Laboratory (Mississippi) and the Virginia Institute of Marine Science were examined, but no *I. agilis* or *I. gouldeni* were found. These samples were from the following states: New Hampshire, New York, Virginia, Florida, Mississippi, Louisiana, Minnesota, Montana, Colorado, Idaho, Nevada, Wyoming, Oregon, Washington, Texas, and Saskatchewan, Canada. In 1977, more samples from the USNM collection were examined. These were from the Mississippi State University collection, and in one of the samples from Franklin County, Alabama, 6 female specimens of *I. gouldeni* were found.

Although samples were not examined from the whole U.S., those examined do indicate that *I. agilis* is not a cosmopolitan species, unlike its well-known U.S. relative, *I. spinifer*, which was found in many of the samples from a wide range of states. *I. gouldeni* appears to be relatively common, as is its closest relative, *I. sordidus*.

At present, the only recorded occurrence of *I. agilis* in the United States has been made by the staff of the Academy of Natural Sciences of Philadelphia, from the Potomac River, Maryland. Specimens have been collected from 9 locations (Sta. 14, 15, 20, 22, 24, BE, BU, PO) distributed along 50 river miles from Watt's Branch, the most northern location, down to Aquia Creek, the most southern site.

During preparation of this paper, mini-core samples sent to the Academy for *Ilyocryptus* identifications contained specimens of *I. agilis*, *I. gouldeni*, and *I. spinifer*. They were collected from Tidemill Marsh on the James River, Virginia, by the staff at Virginia Institute of Marine Sciences. Tidemill Marsh is a tidal freshwater estuarine system. This is only the second area from which *I. agilis* has been reported, and the fourth area where *I. gouldeni* has been found. The areas with *I. gouldeni* are more temperate, from southern Maryland to east Texas, perhaps indicating a preference for warmer waters.

It is possible that specimens of *I. agilis* have occurred in the United States and have been erroneously labeled *I. sordidus*. This is also true of *I. gouldeni* if identifications were based on E. A. Birge's 1910 description found in Ward and Whipple's *Freshwater Biology* (1959) and in R. W. Pennak's (1953) *Freshwater Invertebrates of the United States*. The illustrations in these sources as well as the description provided concerning preanal and postanal spine counts describe morphological characteristics of *I. gouldeni*; the key, however, attributes these characteristics to *I. sordidus*. It is highly probable that there have been many specimens of *I. gouldeni* wrongly labeled *I. sordidus*. For example, a master's thesis by Shih Chien (1969) on the summer Cladocera of the Pearl River system in Mississippi lists, and illustrates, *I. sordidus* as having "eight to ten spines on the proximal curve of the postabdomen, the proximal one being the longest and the two nearest the anal opening small." Chien's camera lucida illustration does not resemble *I. sordidus*'s postabdomen at all. My experience with *I. sordidus* is that even at a very early stage the postabdomen has at least 10–12 preanal spines, all the same length, since newly hatched young are miniature replicas of adults, which have 12–14 spines. The description given by S. Chien fits *I. gouldeni*. Since samples from Texas and from Alabama (USNM Acc. No. 279470, lot #945) contained the new species, it is likely to be found in the neighboring state of Mississippi. This example indicates that identification of the genus *Ilyocryptus* in the U.S. is highly dubious, if based on keys in the two popular freshwater biology publications previously mentioned.

With the addition of *I. agilis* and the new species *I. gouldeni* to the currently confused *Ilyocryptus* keys in the United States, it may be quite some time before accurate accounts of the genus' distribution across the U.S. are available.

I give below an English translation of N. N. Smirnov's (1976) key to the species of *Ilyocryptus.* The new species *I. gouldeni,* is similar in form to characteristics presented in numbers 3, 4, 5, and 7 of the key. The antennule (key character no. 6) of *I. gouldeni* does not have a series of small spines, but does have a "bumpy" or rough area midway on the outer margin. This area is difficult to see as it has a tendency to collect bits of detritus. The gross morphology of the animal most closely resembles that of *I. sordidus,* so that if placed in Smirnov's key, it would then be necessary to separate the two by an additional characteristic, the number of spines on the proximal part of the postabdomen. *I. sordidus* has 12–14 small spines (subequal in length) on the proximal part of the postabdomen, while *I. gouldeni* has 8–9 spines, increasing in length as they near the natatory setae.

Key to the Species of *Ilyocryptus*

1 (12) Shell smooth
2 (3) Anal opening at the distal part of postabdomen
1. *I. acutifrons* Sars, 1862
3 (2) Anal opening at middle part of postabdomen
4 (11) Length of antennule exceeding breadth by less than 8×
5 (10) Lateral spines of postanal part of postabdomen longer than preanal spines
6 (9) Antennule without small spines on outer margin
7 (8) Preanal margin of postabdomen convex
2. *I. sordidus* (Leiven, 1848)
8 (7) Preanal margin of postabdomen almost straight
3. *I. silvaeducensis* Romijn, 1919
9 (6) Antennule with small spines (teeth) on anterior margin (these teeth weak) 4. *I. agilis* Kurz, 1878
10 (5) Lateral spines of postanal margin of postabdomen shorter than preanal 5. *I. brevidentatus* Ekman, 1905
11 (4) Antennule slender, length 8–10× greater than width
6. *I. spinifer* Herrick, 1882
12 (1) Shell pitted or with a lateral process (not smooth)
13 (16) Shell with pits
14 (15) Postabdomen without indentation on dorsal margin, and without numerous small spines (teeth) on distal part of dorsal margin 7. *I. tuberculatus* Brehm, 1913
15 (14) Postabdomen with distinct indentation on dorsal margin

and with numerous small spines (teeth) on distal part of dorsal margin 8. *I. verrucosus* Daday, 1905

16 (13) Shell with lateral process
9. *I. cornutus* Mordukhai-Boltovskoi and Chirkova, 1972

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